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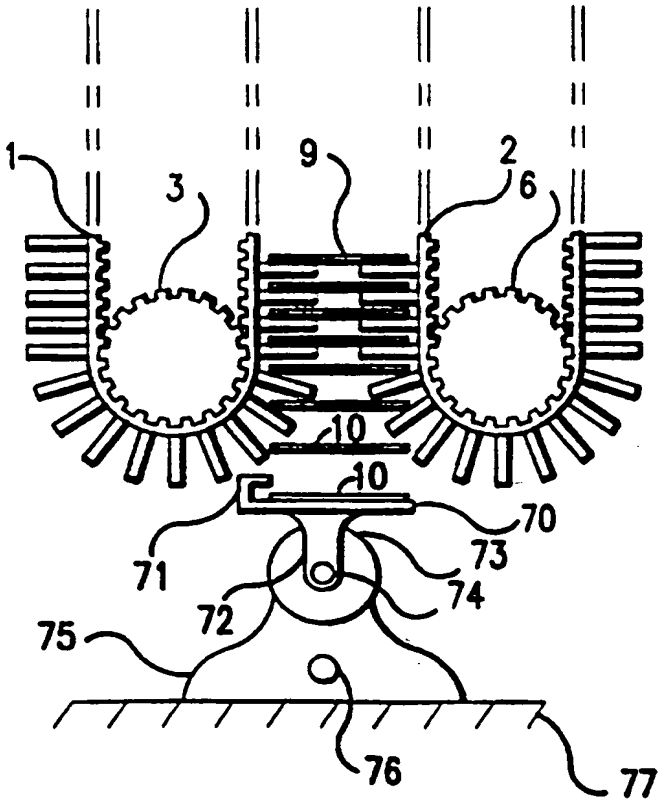
(54) Title: SLIDE TRANSPORT SYSTEM

(57) Abstract

A transport device conveys objects, such as microscope slides (9), from one level to another. The transport device includes a pair of belts (1, 2), the belts (1, 2) having a plurality of treads affixed to the outside surfaces of the belts (1, 2). The belts (1, 2) are driven in opposite directions, so that the treads which face each other move in the same direction, either up or down. Each slide (9) is cradled by a pair of treads, and is moved up or down, while remaining in a generally horizontal position. The transport device can link two or more components of laboratory equipment, so as to produce a larger system that is fully automated. For example, the transport device can convey slides from an automated smear maker to a staining device, without the need for manual intervention. The invention also includes components for loading the slides onto the transport device, and for inverting the slides after they have been transported.



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SLIDE TRANSPORT SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to the field of materials handling, and, in particular, provides an apparatus and method for transporting objects, such as microscope slides, along a vertical path.

The primary purpose of the present invention is to integrate disparate components of laboratory equipment, so that the components can cooperate as a unified, fully automated system. In one example, the invention provides means for transporting microscope slides between a first device which automatically creates a blood smear, and a second device used to stain the slides, wherein the first and second devices are spaced apart vertically from each other. The invention makes it possible for the smear maker and the staining device to work automatically and independently, because the slides can be transported reliably from one device to the other without manual intervention.

Many devices have been used to convey specimens from one location to another, in clinical laboratories. However, most of these devices either require grasping the specimen, or require an array of trays or other carrier devices to transport the specimens. It is usually inconvenient and impractical to grasp a microscope slide, either because the slide is fragile, or because the specimen, or the indicia imprinted on the slide, can easily be abraded and thus obliterated. Furthermore, these devices of the prior art are often expensive and prone to failure.

An example of a device for automatically creating a blood smear on a microscope slide is described in U.S. Patent Application Serial No. 08/477,980, filed June 7, 1995, the disclosure of which is incorporated

by reference herein. The present invention can be used to transport slides from the device shown in the latter reference, or from similar devices, to other pieces of laboratory equipment which are located at different levels relative to the ground. The invention is not limited to use with the above-described smear maker, but can be used to transport slides, or other objects, from one vertical position to another.

SUMMARY OF THE INVENTION

The present invention comprises a pair of opposed belts, the belts having external treads. The belts are arranged vertically, so that the external treads define horizontally-oriented shelves which are capable of holding slides, or other objects, in a generally horizontal orientation. The movements of the belts are preferably synchronized such that the slides continue to be conveyed in their horizontal orientation while the belts move. Microscope slides, cradled between the treads of opposite belts, are transported vertically from, for example, a smearing apparatus at one level to a staining apparatus at a lower level.

The present invention also includes means for synchronization and buffering between different components which operate operate at different and sometimes random rates. In addition, the invention can provide processing of its own, such as the drying of slides.

The invention also includes a device for loading a slide onto the transport mechanism. A carriage, having an attached tongue, moves horizontally along a shaft. The tongue defines a flat surface, preferably with lips at its ends, for holding the slide. When the carriage is moved, the tongue delivers the slide to the belts by moving into the

space between opposing treads, and thereby allowing the slide to become supported by the pair of treads. The carriage then retracts the tongue, preferably after the belts have moved slightly so that the slide will not be affected by the retraction.

The invention therefore has the primary object of providing an apparatus and method for transporting microscope slides in a vertical direction.

The invention has the further object of providing means for cradling microscope slides without disturbing the integrity of the specimen contained on the slides, or of identifying indicia imprinted on the slides.

The invention has the further object of providing means for handling microscope slides very gently, by cradling them in a soft rubber-like support.

The invention has the further object of providing an interim storage means for slides, so that slides can be efficiently transported between two devices which process slides at differing rates.

The invention has the further object of providing a means for synchronization such that slides can be passed from one device to another when the devices operate at different or random rates.

The invention has the further object of reducing the cost of transporting and processing microscope slides.

The invention has the further object of providing a method and apparatus for loading slides onto, and discharging slides from, a vertical transport mechanism.

The invention has the further object of providing a method and apparatus for inverting or flipping slides as they are discharged from a vertical transport device.

The reader will recognize other objects and advantages of the pres-

ent invention, from a reading of the following brief description of the drawings, the detailed description of the invention, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 provides an elevational view of the slide transport device of the present invention.

Figure 2 is a cross-sectional view taken along the lines 2-2 of Figure 1.

Figure 3 is a partial elevational view of the slide transport device of the present invention, showing the preferred apparatus for insertion of slides.

Figure 4 is a cross-sectional view, taken along the lines 4-4 of Figure 3, further illustrating the apparatus for insertion of slides.

Figure 5 provides a partial elevational view, similar to that of Figure 3, showing a slide being lifted off of the tongue which has carried the slide to the transport device of the present invention.

Figure 6 provides a cross-sectional view, taken along the line 6-6 of Figure 5.

Figure 7 provides an elevational view of an alternative form of the present invention, showing a pair of belts in a tilted arrangement, for transporting slides along a tilted path.

Figure 8 provides a cut-away perspective view of an assembly including the transport device of the present invention in conjunction with an automated smearing apparatus.

Figure 9 provides a cut-away perspective view of an assembly includ-

ing the transport device of the present invention in conjunction with both an automated smearing apparatus and an automated staining device.

Figure 10 provides a fragmentary elevational view of another embodiment of the present invention, which embodiment includes a mechanism for automatically turning slides upside-down after they have been ejected from the transport device.

Figures 11, 12, and 13 provide diagrams illustrating successive stages in the operation of the device of Figure 10.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figure 1, the slide transport device of the present invention includes a pair of belts 1 and 2 arranged in a generally vertical orientation. Belt 1 has a pair of sprocket pulleys 3 and 4 which mesh with the corresponding inner treads 13 on the inside surface of the belt. Belt 1 also has a plurality of outer treads 7, located on the outer surface of the belt. Belt 2 is identical to belt 1, having sprocket pulleys 5 and 6, inner treads 14, and outer treads 8. The belts are preferably made of rubber, or a rubber-like material, or of some other compliant material. The invention is not limited to rubber or rubber substitutes. The belts are spaced apart from each other, as shown, so that slides 9 can be inserted between them. The distance between the belts is greater than a dimension of the slides, so as to allow the slides to fit easily between the belts. But the distance between the outer treads must be less than a dimension of the slides, so that each slide can be supported by a pair of outer treads.

When the pulleys of belt 1 rotate in a direction opposite to that of the pulleys of belt 2, the outer treads which face each other move in the

same vertical direction. The rotation of the pair of pulleys 3 and 4 is synchronized with the rotation of the pair of pulleys 5 and 6, such that the outer treads 7 and 8 are positioned to cradle the slides in a horizontal position, as shown. Thus, the slides move vertically. The slides can be moved either up or down, depending on the direction of rotation of the pulleys.

The movement of the outer treads around the pulleys facilitates the loading of slides into, and the discharge of slides from, the transport mechanism. As is shown in Figure 1, the outer treads are spaced farther away from each other when they are traveling around the pulleys, than when they are moving along straight paths. For example, at the bottom of Figure 1, one can see that the movement of the outer treads around the pulleys releases the slides from the transport device, because the treads become separated by a distance greater than the length of the slides.

In the embodiment shown in Figure 1, the belts are generally parallel to the path of travel of the slide. If one desires to move the slides along a path which is tilted, the belts can be tilted at the required angle, and pulleys can be adjusted so as to position the treads such that they maintain the slides in a horizontal orientation. Figure 7 shows this alternative embodiment, in which the belts are oblique relative to the path of the slide. In Figure 7, the belts 1 and 2 can transport a slide both vertically and horizontally. The amount of horizontal travel is generally less than the amount of vertical travel. The outer treads located on adjacent surfaces of the belts are still synchronized due to the synchronization of the movements of the pulleys, so as to maintain the slides in a horizontal orientation.

When the slides are being transported downwardly, and when they

reach the bottom of the transport device, the slides fall off the end of the belt as the treads separate, as indicated by reference numeral 10 in Figure 1. If it is necessary to flip the slides upside down, a striker bar 11 may be positioned in the vicinity of the bottom of the device, as shown, to cause the slides to rotate as they fall.

Figure 2 shows slides 9 as they are cradled by the outer treads 8 of belt 2. In Figure 2, the width of belt 2 is less than the width of the slide. The width of the belt can be made equal to, or larger than, the width of the slide. It is also possible to have a plurality of narrow belts, provided that the treads of each of the narrow belts are synchronized.

The preferred means for synchronizing the belts is simply to make all of the pulleys of equal diameter, and to make them turn at the same rate. The pulleys can therefore be adjusted, on a one-time basis, so that the treads are aligned, for example, as shown in Figure 1. The belts will retain their synchronization indefinitely. One could use other arrangements for synchronization. For example, one can vary the size of the pulleys, while varying the speed of the motors driving the pulleys, so that the desired synchronization is maintained. Any arrangement that aligns the treads in the desired manner should be considered within the scope of the present invention.

Figure 4 shows the apparatus and method for loading the transport device of Figure 1. An introducer apparatus 20 is shown at the moment when it is injecting a slide into the region between the belts. The introducer apparatus includes a carriage portion 25 and tongue 28. The tongue holds slide 9 which is cradled in a depression between lips 21 and 29. The carriage includes bearing 23 which is mounted around bar 22, so that the carriage travels horizontally along the bar. The carriage can

be powered by various conventional means, not shown, such as a screw or a timing belt. Figure 3 shows that the introduction of the slide is performed when the opposing treads 8A and 8B are located slightly below the bottom surface of slide 9.

Figure 5 shows how the slide is lifted away from the tongue. The belts are simply rotated in the directions indicated by arrows 25 and 26. This rotation lifts slide 9 away from lip 21, and thus from the tongue. As shown in Figure 6, having been elevated above the tongue, slide 9 will not move when the tongue is withdrawn. Carriage 20 is now free to retract, by moving to the left.

The tongue is constructed so that it fits within the space between facing outer treads. Also, the width of the tongue is less than the length of the slide, so that the slide will overhang the tongue, as is visible in Figures 3 and 5. Thus, the tongue can simply deposit the slide onto a pair of outer treads. The tongue need not ever be in direct contact with the outer treads.

Figure 8 shows an embodiment of the present invention which includes the transport device described above, in combination with an automated smear making apparatus. The smear making apparatus is similar to what is described in U.S. Patent Application Serial No. 08/477,980, cited above. The latter apparatus includes magazine 32 containing microscope slides 9, a module 33 which prints identifying indicia on the slide, and a smearing element 35 which spreads blood across the slide. The smear making apparatus also includes a carriage which transports the slides horizontally from the smear making area to the vertical transport. Reference numeral 1A indicates a slide on which a smear has just been made. Reference numeral 1B indicates a slide bearing a smear, the slide 1B having been

pushed onto the vertical transport of the present invention.

In the apparatus of Figure 8, the slides are exposed to heated air, blown by fan 114, and are dried as they travel. The drying of the slides is an example of how the slides can be processed while they are being conveyed by the transport device. Other forms of processing can be performed while the slides are in transit. At the end of their travel, the slides are deposited in a tray 1F.

Figure 9 shows another embodiment of the present invention which includes the slide transport device described above, in combination with both an automated smearing apparatus and a commercially available stainer. The slides are first prepared in the smearing apparatus, as described above, and are delivered automatically to the vertical transport device, which carries them to the stainer, and deposits them upside-down onto a horizontal surface. The stainer, indicated generally by reference numeral 303, includes a worm drive, defined by cylindrical members 304 and 305 having helical protrusions, which transport slides 9 across the horizontal surface. The slides are then subjected to various chemicals as they move along that surface.

The length of the belt and the spacing of the treads determines the capacity of the device to store slides, and to act as a buffer between components of a larger system. In the example of Figure 9, buffering is useful because the processes of smearing and staining are non-synchronous. Also, the capacity of the belt allows time for the drying of slides, which may be enhanced by the use of heated air.

Figure 10 shows an alternative embodiment which includes a device that flips the slides upside-down, and deposits them onto a target surface, which, in the example of Figure 9, can be the platen of the stainer. The device includes pivoting shelf 70 which has a protrusion at

one end, the protrusion defining notch 71. The shelf is attached to bracket 72 which pivots about axle 74, which is connected to motor 73. Motor 73 is attached to base 75 which rests on target surface 77. Pin 76 is affixed to the base, and protrudes therefrom, in a direction toward the reader.

When the slide 10 falls off the treads of belts 1 and 2, the slide will drop onto shelf 70. Then, as shown in Figure 11, shelf is rotated counterclockwise by the motor, and the slide moves into notch 71, due to gravity. In Figure 12, the shelf has moved to its final angular position, prior to which the slide has flipped to an upside-down position when the angle of the shelf crosses the vertical. The slide will tend to flip when the angle of rotation of the shelf has exceeded about 90°. When the shelf has reached this final angular position, pin 76 penetrates an aperture in the shelf, not shown, creating a reaction force, designated F, which forces the slide out of the notch. Figure 13 shows the slide 10 falling onto target surface 77. The shelf is returned, by the motor, to the starting position shown in Figure 10, and the shelf is ready for another cycle of operation.

Although the invention is especially useful in transporting flat objects such as microscopic slides, it is not limited to use with flat objects. Objects having a significant vertical dimension can also be transported by the present invention, as long as the vertical dimension of the objects is less than the distance between adjacent treads of a particular belt.

While the invention has been described with respect to particular embodiments, the reader skilled in the art will recognize that the invention can be further modified. Such modifications should be considered

within the spirit and scope of the following claims.

What is claimed is:

1. Apparatus for transporting objects along a path which extends at least partly vertically, the objects having a dimension, the transport mechanism comprising a pair of belts, the belts having external surfaces, the belts having external treads extending from the external surfaces, the belts being arranged such that at least portions of the external surfaces are arranged so that said surfaces face each other, wherein the external treads extending from the surfaces of the belts define pairs of treads spaced apart by a dimension less than the dimension of the objects, said pairs of treads comprising means for holding the objects in a generally horizontal orientation, the apparatus further comprising means for moving the belts, such that said pairs convey the objects along said path.

2. The apparatus of Claim 1, wherein the belts have internal surfaces and internal treads extending from the internal surfaces, wherein the moving means includes pulley means for engaging the internal treads, the pulley means being positioned adjacent the internal surfaces of the belts.

3. The apparatus of Claim 2, further comprising means for moving the pulley means of one belt, and for moving the pulley means of the other belt, wherein the pulley moving means comprises means for moving said one belt in a direction opposite to a direction of movement of said other belt.

4. The apparatus of Claim 1, further comprising a striker bar, positioned adjacent at least one of the belts, the striker bar comprising means for affecting a trajectory of one of said objects as said objects are ejected from the apparatus.

5. The apparatus of Claim 1, further comprising an inversion device positioned in a vicinity of the belts, the inversion device comprising a shelf mounted for rotation by a motor, and means for ejecting an object from the shelf when the shelf has been rotated through an angle greater than about 90°.

6. The apparatus of Claim 1 in combination with an automated smear maker, the smear maker comprising means for storing a plurality of slides, means for imprinting indicia on the slides, means for creating smears on the slides, and means for conveying the slides, wherein the conveying means comprises means for conveying the slides to a vicinity of the belts, wherein the slides can be transported away from the smear maker.

7. The apparatus of Claim 6, further comprising an automated staining device, the staining device being positioned to receive slides transported by the belts, whereby the apparatus comprises means for transporting slides from the smear maker to the staining device.

8. The apparatus of Claim 1, further comprising an apparatus for loading an object onto a pair of said outer treads, the loading apparatus comprising:

a carriage mounted for translational movement along a shaft,

the carriage being connected to a tongue, the tongue including a generally flat surface capable of holding an object from below,

the carriage being positioned such that the tongue can move into a space between the outer treads of the belts, such that an object held on the tongue can be transferred to the outer treads.

9. The apparatus of Claim 8, wherein the tongue includes a pair of lips, the lips defining a depression between the lips, wherein the depression is sized sufficiently that the object can rest within the

depression.

10. The apparatus of Claim 1, wherein the belts are generally parallel to said path.

11. The apparatus of Claim 1, wherein the belts are oblique to said path.

12. The apparatus of Claim 1, wherein the belts are endless belts, the belts having internal surfaces, the internal surfaces of both belts being engaged by a pair of pulleys, such that the outer treads pass around the pulleys, wherein the treads passing around one pair of pulleys comprise means for discharging the objects from said path.

13. The apparatus of Claim 1, further comprising means for processing the objects while the objects are being conveyed along said path.

14. Apparatus for transporting objects along a path, the apparatus comprising a pair of endless belts arranged for movement around pairs of pulleys, the belts having external surfaces which are provided with a plurality of treads extending from the external surfaces, and means for moving the pulleys such that the belts move in opposite directions, the belts being arranged to define a plurality of facing spaced-apart pairs of said external treads, each spaced-apart pair of treads comprising means for supporting the objects in an orientation which is generally perpendicular to said path.

15. The apparatus of Claim 14, further comprising means for loading said objects onto said pairs of treads.

16. The apparatus of Claim 15, wherein the loading means comprises tongue means for holding said objects, the tongue being attached to a movable carriage positioned such that the tongue can be injected into a space between said pairs of treads.

17. The apparatus of Claim 14, further comprising means for inverting the objects as they are discharged from the treads.

18. The apparatus of Claim 14, further comprising means for processing the objects while the objects are being transported along said path.

19. A method of transporting objects from one level to another level, the method comprising the steps of:

a) loading an object onto a support surface defined by a pair of treads which extend, respectively, from a pair of spaced apart belts, and

b) moving the belts such that the pair of treads move in a same direction and at a same rate, until the object supported on said pair of treads has been moved to a desired position.

20. The method of Claim 19, wherein the objects are transported along a path which begins at a first level and ends at a second level, the second level being below the first level,

and wherein the loading step comprises transporting the object on a generally flat surface, to a vicinity of the treads, such that the object rests upon the treads as well as on said flat surface,

and wherein the loading step is followed by the step of moving the belts in a direction opposite to the path of the object, by a distance sufficient to disengage the object from said flat surface, and retracting the flat surface away from the vicinity of the belts.

21. The method of Claim 19, wherein the flat surface comprises a tongue having at least one lip disposed at an end of the surface, the lip having a dimension, and wherein the step of moving the belts in a direction opposite to the path comprises moving the belts a distance greater than the dimension of the lip, wherein the object will be unaffected upon retraction of the surface.

22. The method of Claim 19, wherein step (b) is performed simul-

taneously with the further step of processing the objects.

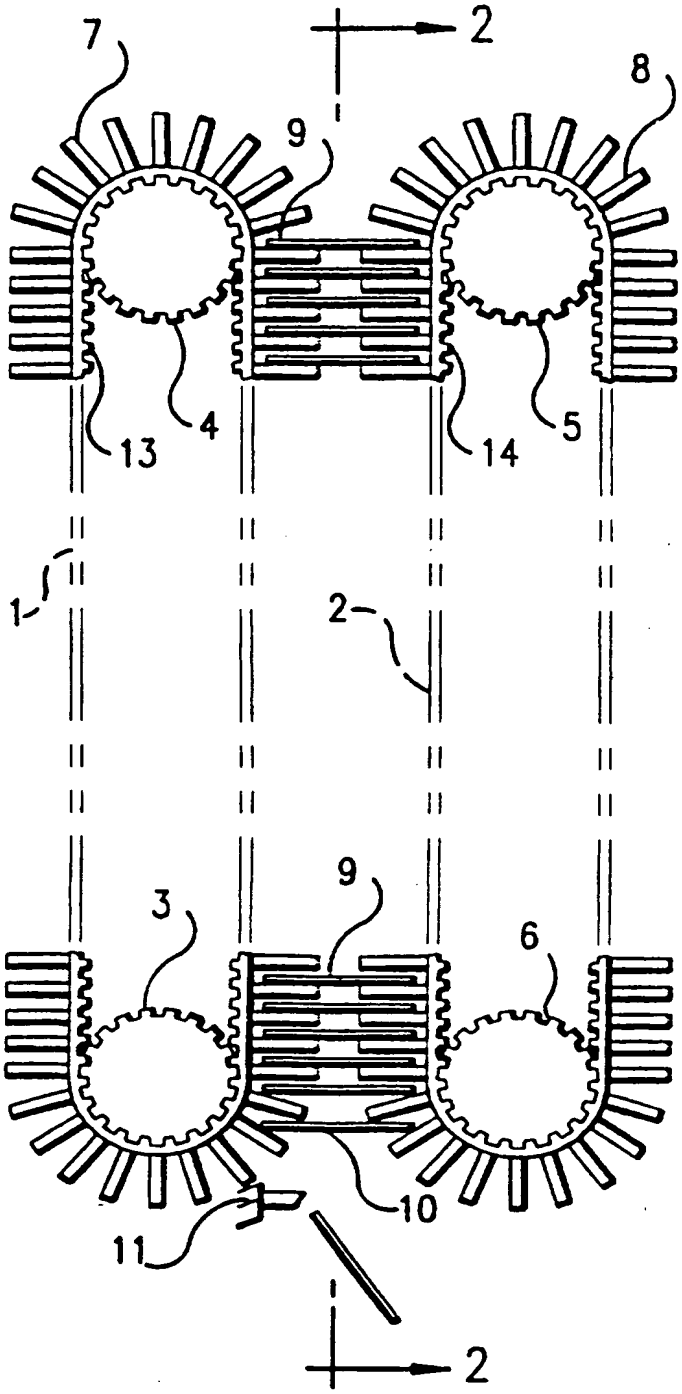

FIG.1

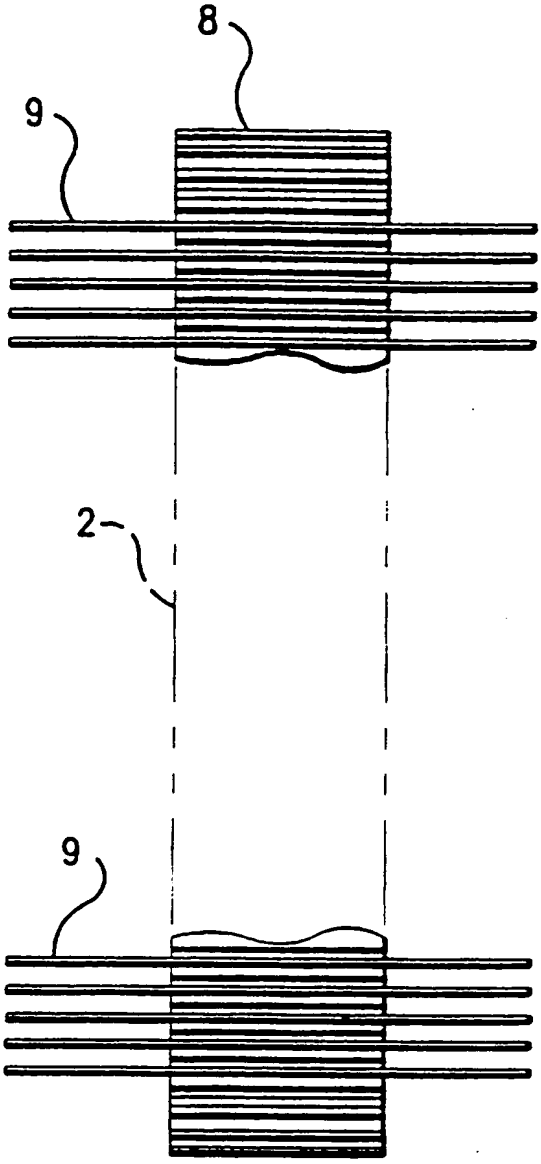

FIG.2

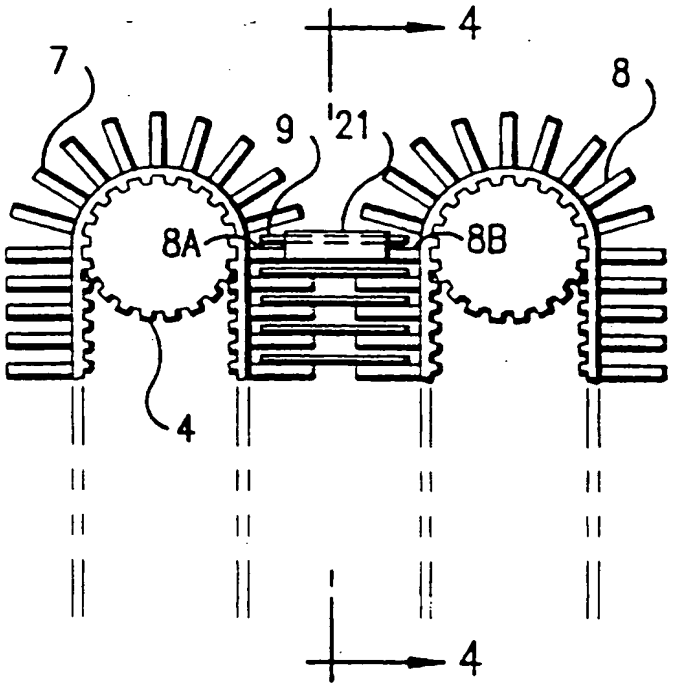

FIG.3

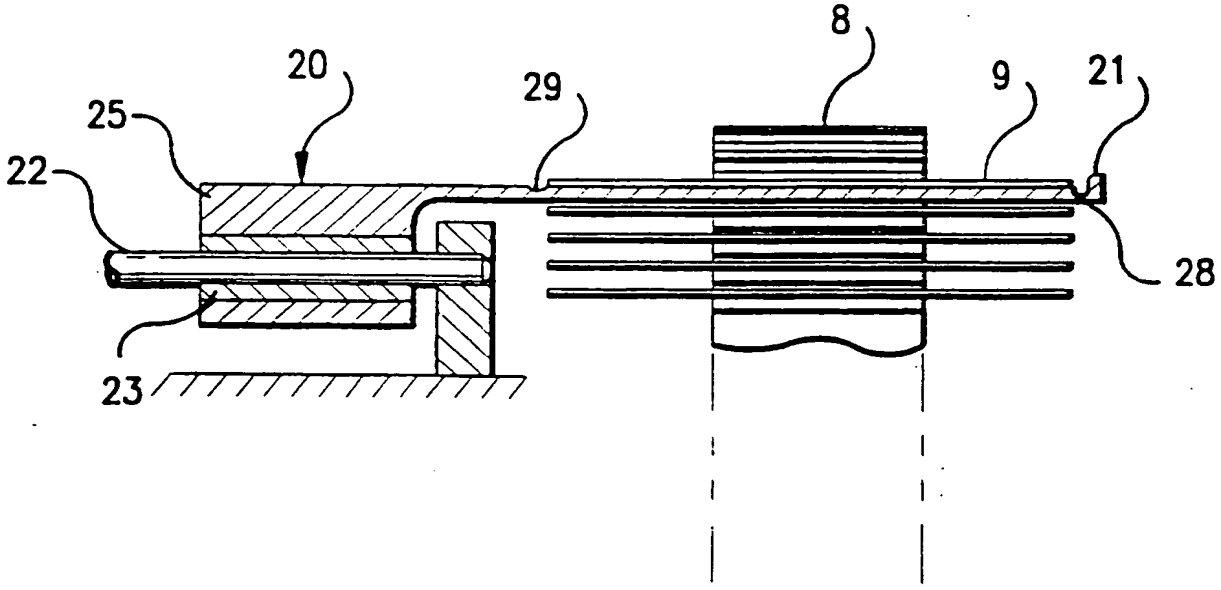

FIG.4

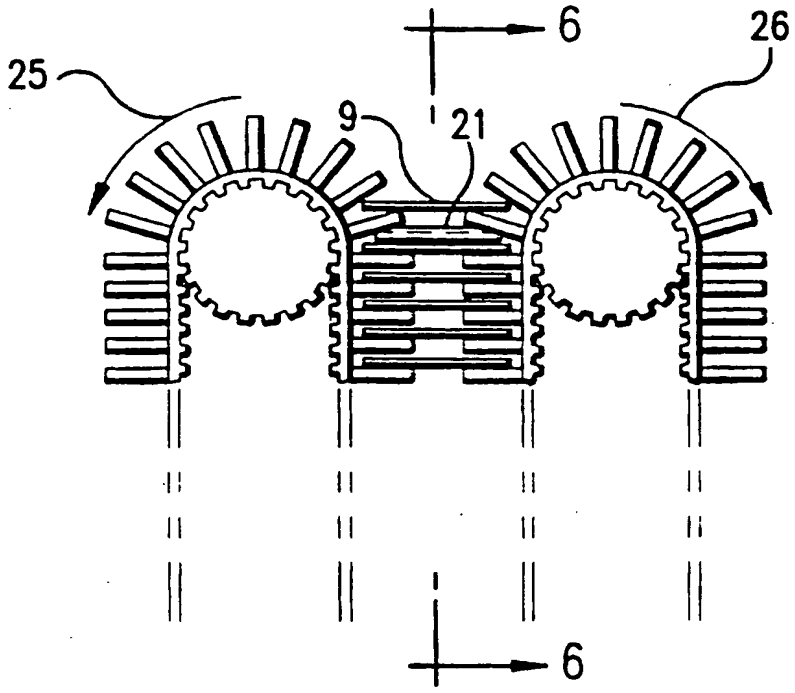

FIG.5

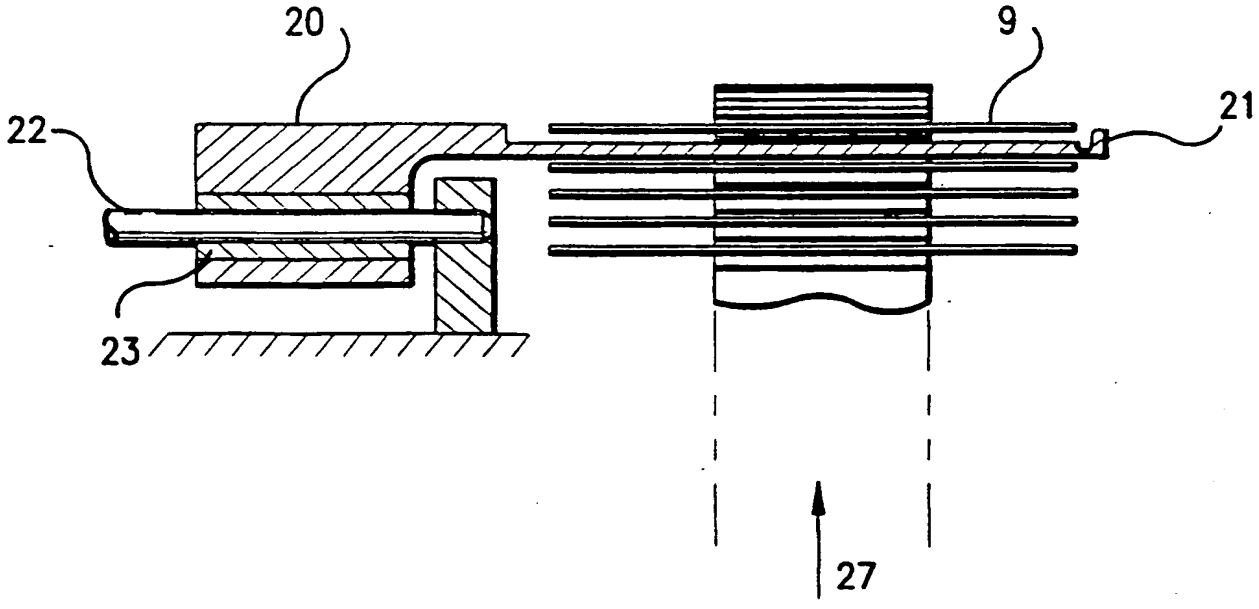

FIG.6

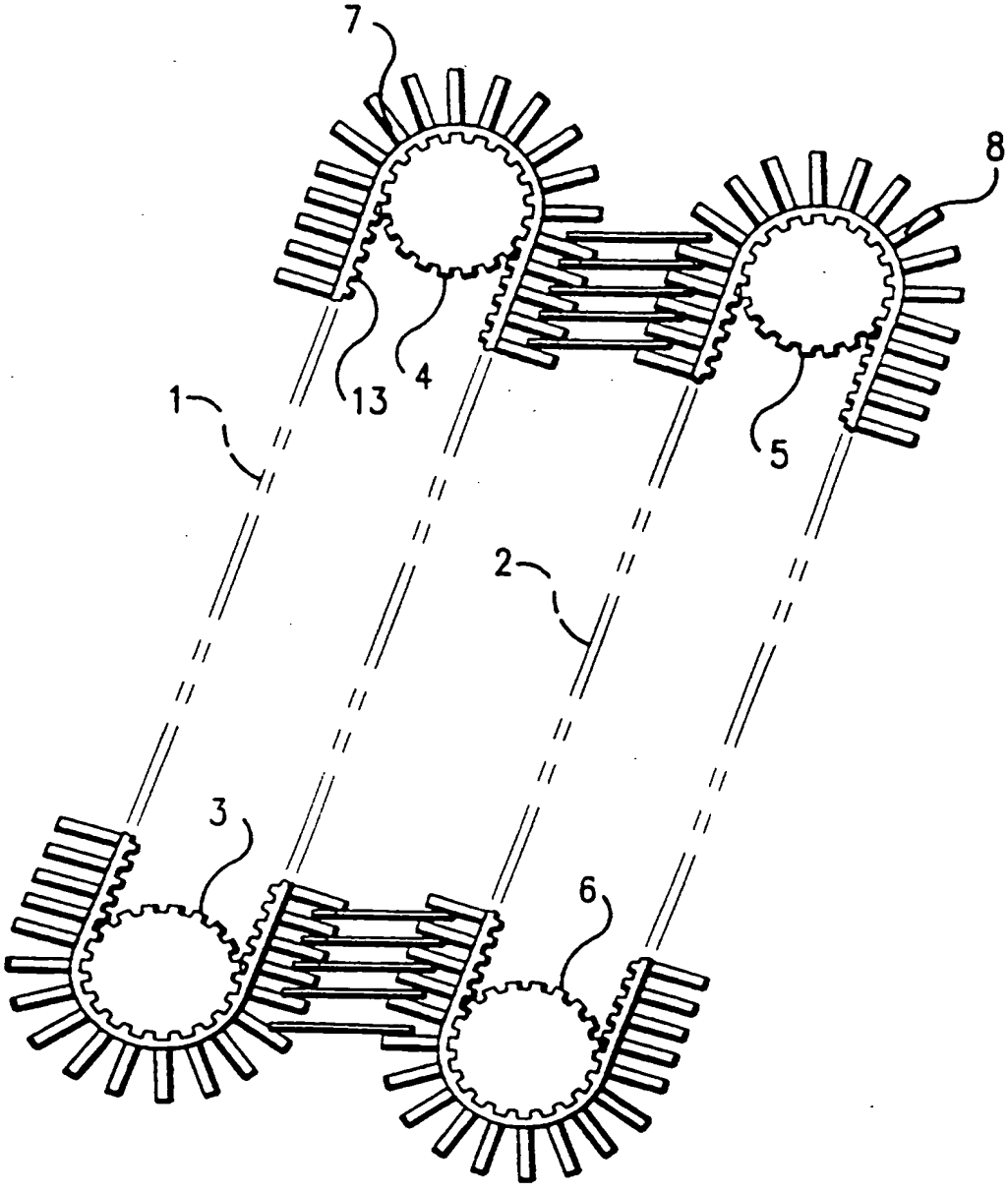

FIG.7

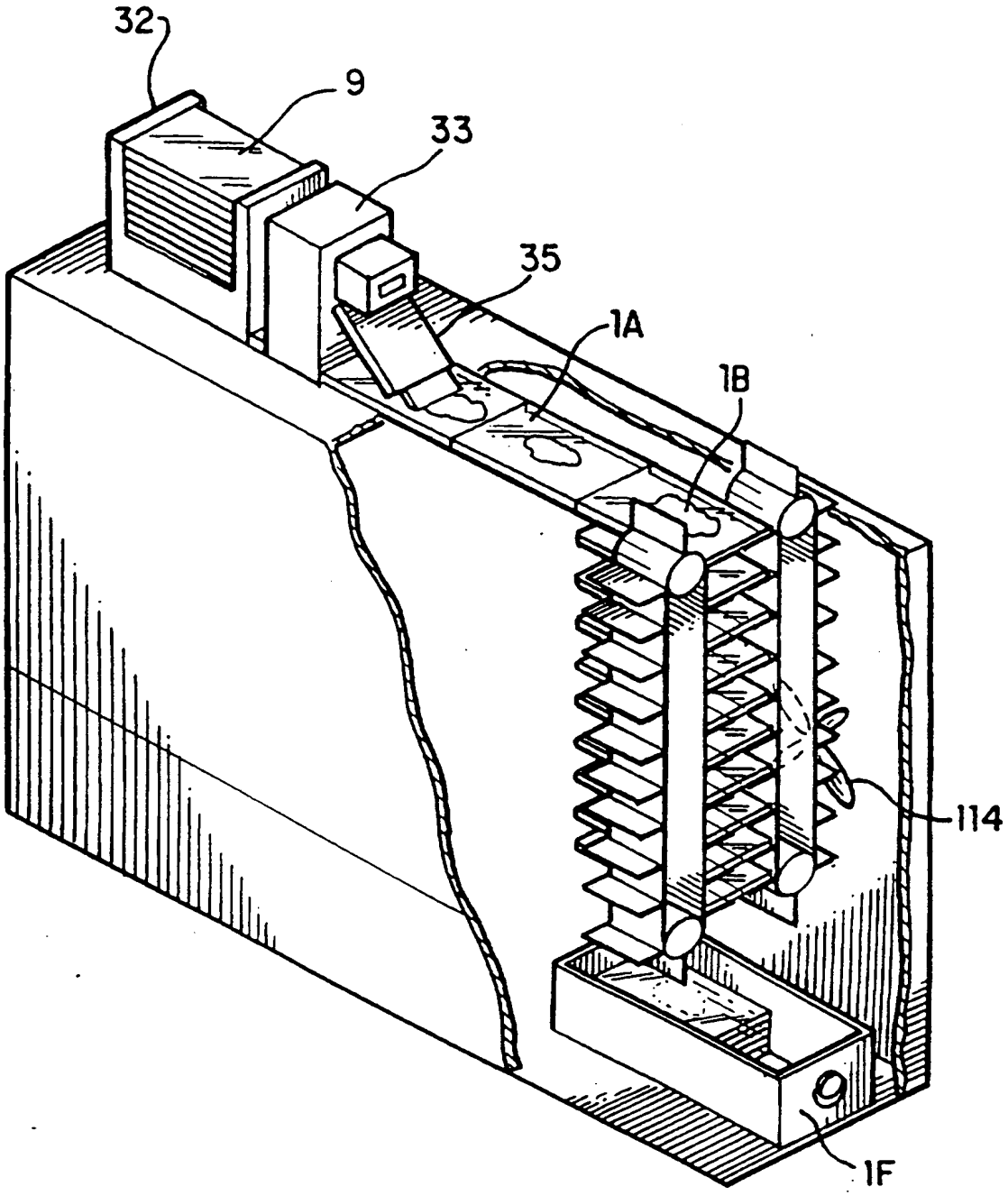

FIG. 8

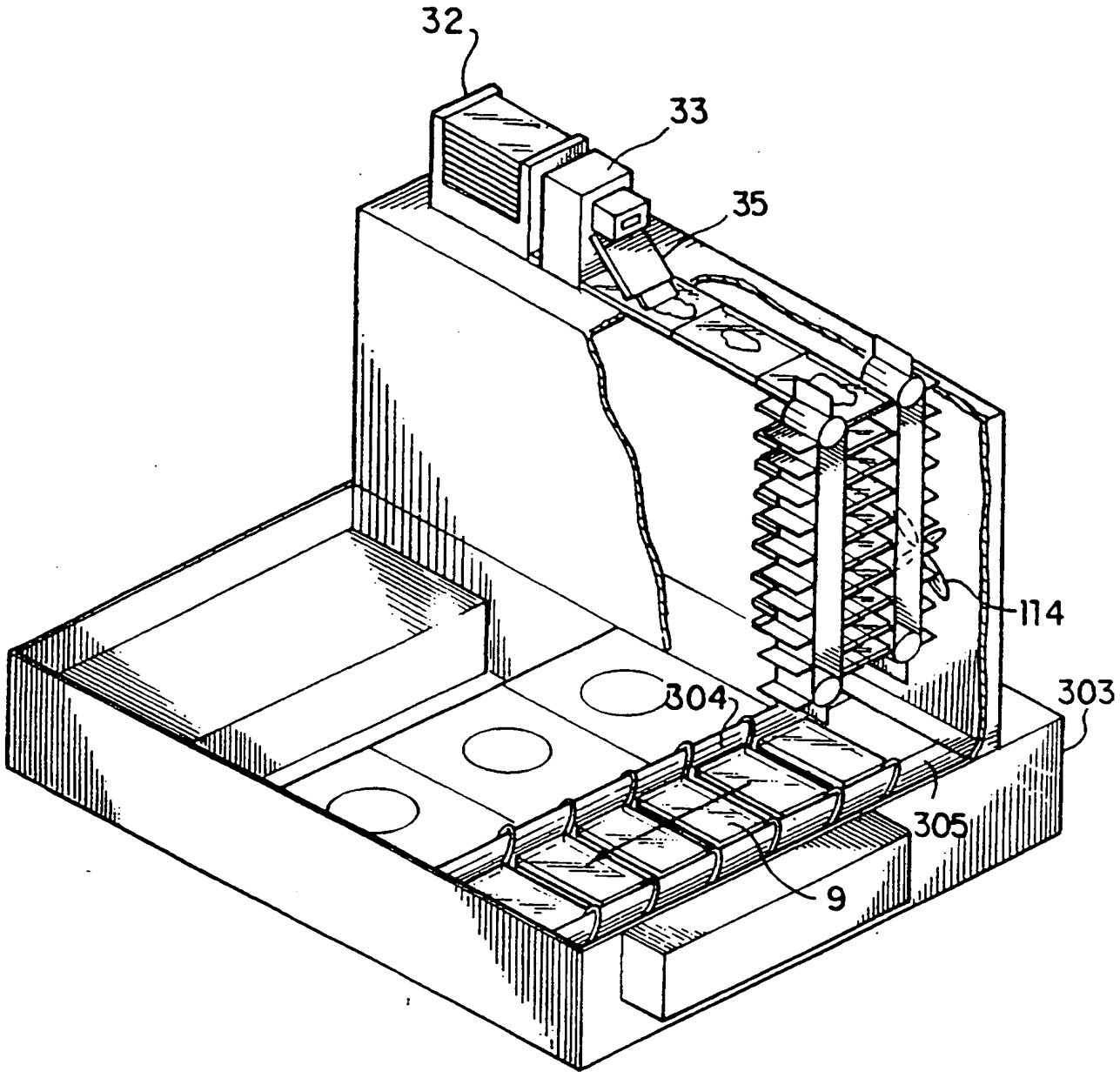

FIG. 9

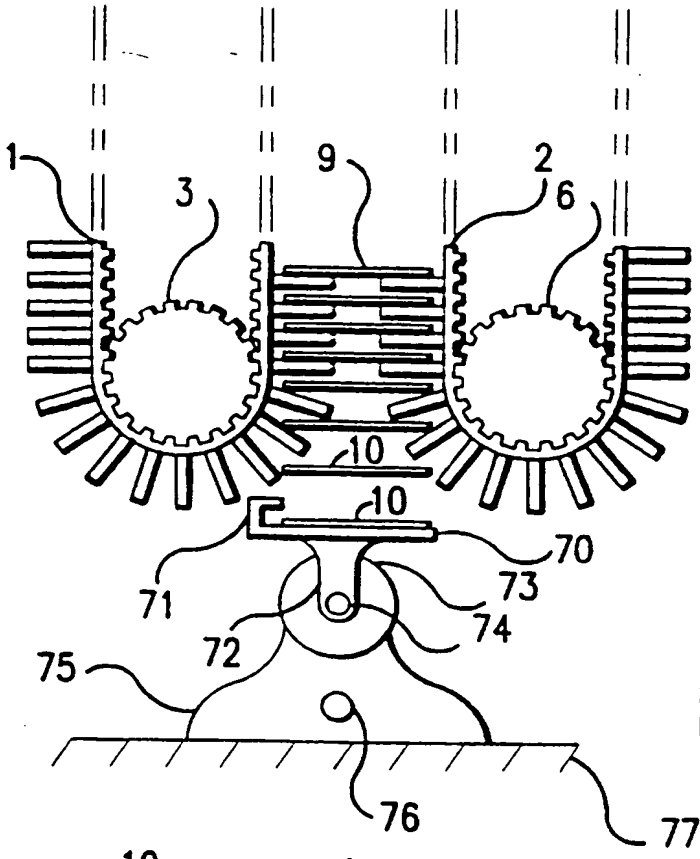

FIG.10

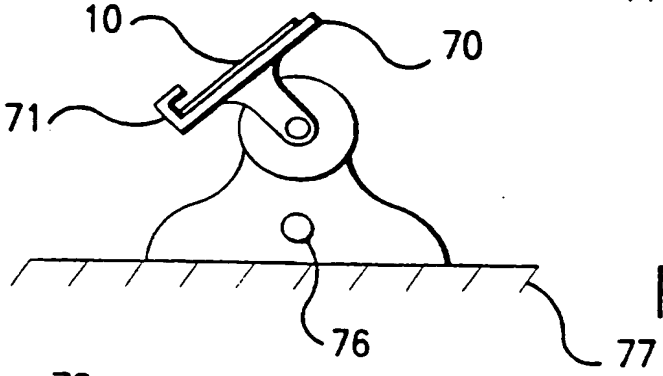

FIG.11

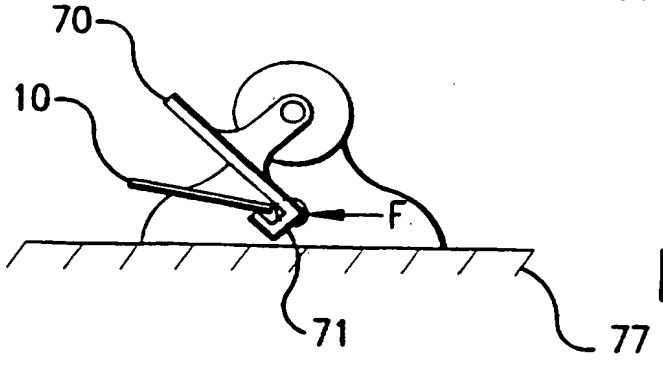

FIG.12

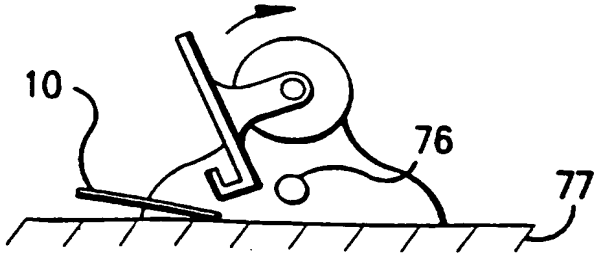

FIG.13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/05301

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G01N 31/10, B65G 15/12
US CL :422/63, 65, 66, 103, 104; 436/43, 44, 46; 198/807, 818, 819, 823

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 422/63, 65, 66, 103, 104; 436/43, 44, 46; 198/807, 818, 819, 823

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,324,957 A (HEJAZI) 28 June 1994, figures 2 and 3, column 3, lines 9-42.	1-3, 10, 12-14, 18, 19 --- 4-9, 11, 15-17, 20-22
Y	US 4,857,272 A (SUGAYA) 15 August 1989, figures 3 and 4	4
Y	US 5,447,690 A (SUGAYA) 05 September 1995, figures 5 and 6.	5 and 17
Y	US 5,209,903 A (KANAMORI et al.) 11 May 1993, figure 7	6 and 7
Y	US 5,149,654 A (GROSS et al.) 22 September 1992, figure 3	8, 15, 16 and 20-22

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 08 MAY 1997	Date of mailing of the international search report 24 JUN 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile N. (703) 305-3230	Authorized officer LONG V. LE Telephone N. (703) 308-0651

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/05301

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,857,471 (SALZMAN et al.) 15 August 1989, figures 2 and 3A; and column 3, lines 47-57	9
Y	US 5,419,871 A (MUSZAK et al.) 30 May 1995, figure 15	11